The JWST Science Calibration Pipeline

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Overview

All James Webb Space Telescope (JWST) observing modes are processed and calibrated automatically to produce analysis-ready products for users:

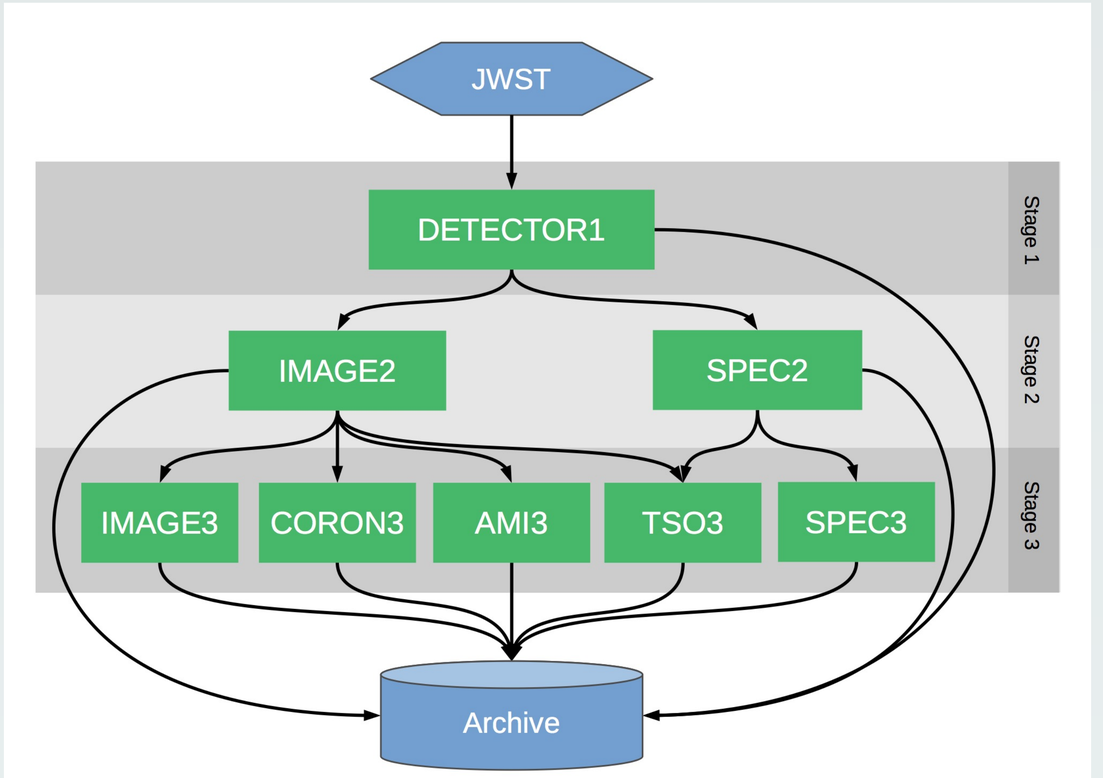
- Direct and Coronagraphic Imaging
- Aperture Masking Interferometry (AMI) Imaging
- Slit-like Spectroscopy
- Integral Field Unit Spectroscopy (IFU)
- Multi-Object Spectroscopy (MOS)
- Wide Field Slitless Spectroscopy (WFSS)
- Time Series Observations (TSO)

Pipeline organized by observing modes, in 3 stages:

1. Detector-level corrections for individual exposures
2. Instrument-level calibrations for individual exposures
3. Combine data from multiple exposures

- All pipeline and step modules written as Python classes
- Callable from command line and from within Python
- Liberal use of public Astropy libraries
- Software data models abstract the connection to disk files

Pipeline Organization and Stages



Stage 1 Corrections

Typical corrections needed for Near-IR and Mid-IR “up the ramp” detector readouts applied to all instruments, e.g.

- Saturation flagging
- Reference pixel correction
- Persistence correction
- Dark subtraction
- Linearity correction
- Jump (CR) flagging
- Slope fitting with CR and saturation removal

Stage 2 Calibrations

Full calibration of individual exposures

Imaging

- WCS Object Construction
- Background Subtraction
- Flat-Fielding
- Flux Calibration
- Image Rectification

Spectroscopy

- WCS Object Construction
- Background Subtraction
- MSA Failed Shutter Flagging
- 2-D Spectral Extraction
- Flat-Fielding
- Stray Light Correction
- Fringing Correction
- Pathloss Correction
- Flux Calibration
- 2-D/3-D Rectification
- 1-D Spectral Extraction

2-D spectral extraction of sources/slits driven by:

- MOS – User-supplied source catalog and MSA slitlet definitions
- WFSS – Source catalog constructed on-the-fly from accompanying direct images of the field

Stage 3 Calibrations

Calibration and Combination of Multiple Exposures

Direct Imaging

- Image Alignment
- Background Matching
- Outlier Detection
- Drizzle Combination
- Source Catalog

Coronagraphic Imaging

- Collect PSF Images
- Align PSF & Target Images
- PSF Subtraction (KLIP)
- Outlier Detection
- Drizzle Combination

AMI Imaging

- Collect PSF Images
- Compute Fringe Params
- Average Fringe Params
- Normalize Target Fringe Params from PSF Fringes

Spectroscopy

- Master Background Sub
- Background Matching (IFU)
- 2-D Outlier Detection
- 2-D/3-D Drizzle Combination
- 1-D Spectral Extraction

TSO Imaging

- 2-D Outlier Detection
- Source Photometry (light curve generation)

TSO Spectroscopy

- 2-D Outlier Detection
- 1-D Spectral Extraction
- White-Light Photometry (light curve generation)

Associations of Exposures

- Meta data for all exposures of a target within a program stored in Association “pool” (simple ASCII csv file)
- Association “rules” (software filters) analyze the pool meta data to find exposures that belong together, e.g.
  - Multiple detector images of a target for mosaicing
  - Same target, same filter for dithered/mosaiced images
  - Off-source background exposures for a target
  - Contemporaneous calibration exposures (flats, wavecals)
  - PSF reference target exposures for coronagraphy and AMI
  - Direct images accompanying WFSS (dispersed) images
- Association files (json text format) contain lists of exposures created by the rules, along with attributes such as their role in the Association (science, background, PSF, flat, etc.)
- Association files are input to the stage 2 and 3 pipelines
  - Pipelines open the list of input files and use the attributes to know where/how to use them, e.g. background subtraction, PSF subtraction, etc.